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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
18 July 2002 (18.07.2002)

PCT

(10) International Publication Number
WO 02/056416 A1

(51) International Patent Classification[7]: H01Q 1/27, A41D 1/00

(21) International Application Number: PCT/IB02/00017

(22) International Filing Date: 4 January 2002 (04.01.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0100775.6 11 January 2001 (11.01.2001) GB

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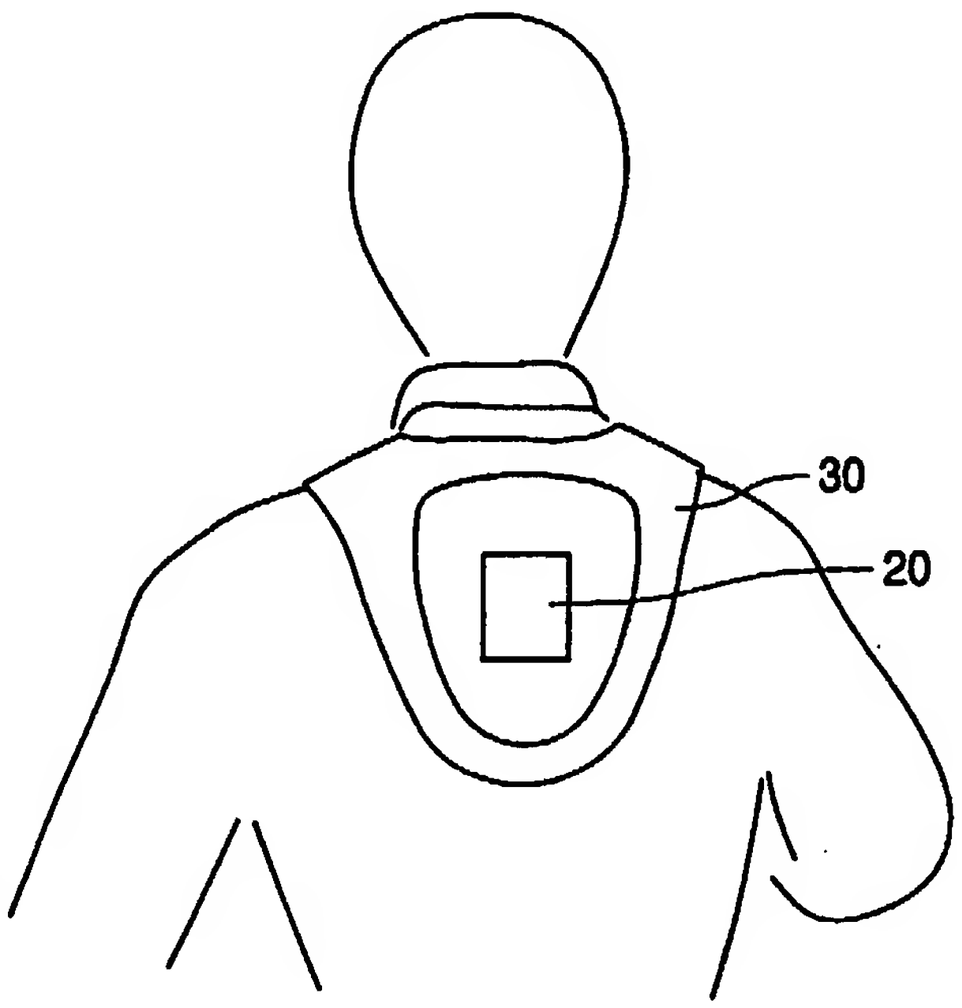
(81) Designated States *(national)*: JP, KR.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: GARMENT ANTENNA



(57) Abstract: An antenna (20) is set in an antenna mounting (30) of size and shape such that the antenna may be accommodated at least in part in the naturally occuring dip between a persons shoulder blades at the upper part of the back. The mounting (30) includes supporting straps (38a, 38b) which extend during use from that part of the mounting hosting the antenna, over the shoulders of the wearer adn down the front of the wearers torso. The antenna mounting (30) is provided in a garment (not shown) suitable for wearing about the upper part of the body. By extending the support straps over the wearers shoulders in this way, the weight of the straps serves to counter balance the weight of the antenna (20) and mounting (30) combined between the front and back of the wearer, so as to be centred about the wearers shoulders. Such weight distribution seeks to improve the comfort of a garment provided with the antenna (20) and mounting (30) and will generally contribute to the correct "hang" of the garment itself. In one arrangement the antenna (20) is a fabric patch antenna.

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DESCRIPTION

GARMENT ANTENNA

The present invention relates to antennas for allowing portable electronic devices to perform wireless transfer of data and in particular, to such antennas incorporated into a garment shaped to be worn about the upper body of a user.

Traditionally, mobile telecommunications equipment including mobile telephones and radio receivers have been provided with their own antenna to form a self contained functional device. More recently, work in the field of wearable electronics has included attempts to combine and integrate electronic equipment, including telecommunications equipment with items of clothing. Such integration can be beneficial in a number of ways including improved ease of carrying electronic equipment, improved functionality and elimination of duplicated components. An example where the last two benefits are realised would be the automatic routing and switching of audio from audio reproduction equipment and a mobile telephone through the same pair of earphones.

In some instances the ability to distribute and integrate equipment in clothing allows for new types of component to be employed which can result in improved performance. An example new component is an antenna of laminar construction such as the one described in International patent application WO-A-01/39326 published on 31st May 2001 claiming priority from British patent application number 9927842.6 (applicants reference PHB 34417) filed on 26th November 1999 in the name of Koninklijke Philips Electronics N.V. entitled 'Improved Fabric Antenna'. The antenna is primarily intended for use with mobile telecommunications applications and comprises first and second spaced layers of electrically conducting fabric, a layer of electrically insulating fabric between the first and second layers, first connection means by which electrical contact is made between the first and second layers, and second

connection means by which the first and second layers are connectable to telecommunications equipment. The arrangement constitutes a so-called 'planar inverted F antenna (PIFA)'.

That antenna is intended for incorporation into a shoulder portion of a garment in the form of a shoulder pad or into a lapel of a garment. However, such an arrangement is not always an option. This may be due to aesthetic reasons, in particular when the garment has no arm portions at all, or no lapel. In the case of garments provided with detachable arm portions, the presence of the arm portion attachment fastenings (such as zips) may rule out the possibility of accommodating a shoulder pad antenna as the antenna can easily get in the way of, or foul correct operation of, the fastening device. There is a need to include an antenna in a garment in an ergonomic and practical way.

It is an object of the present invention to provide an antenna that may be accommodated within a garment, which device seeks to overcome at least some of the above mentioned problems.

In accordance with a first aspect of the present invention there is provided a garment comprising an antenna and means for connection of the same to a portable electronic device to permit wireless communications of said device via said antenna;

characterised in that the garment is shaped to be worn about the upper body of the user and the antenna is supported by an antenna mounting of the garment so that when the garment is being worn the antenna is held in the vicinity of the back between the shoulder blades and the antenna mounting is configured with a shape and size to accommodate the antenna in the vicinity of the back between the shoulder blades.

Such positioning of the antenna takes advantage of the naturally occurring dip between a persons shoulder blades to accommodate at least some of the thickness of the antenna while the garment is being worn. This helps to suppress any apparent bulge in the garment caused by the presence of the antenna.

The antenna mounting may include a body portion configured with a shape and size such that it is capable of being at least partially accommodated in the vicinity of a wearers back between their shoulder blades.

The antenna mounting may include straps which extend during use over the shoulders of a wearer towards the front of the wearers torso. In this case the straps may be configured to extend during use at the front of the wearers torso to at least partially counterbalance the weight of the antenna. By incorporating this arrangement of antenna and antenna mounting in a garment the weight of the antenna is more evenly distributed over the garment and therefore contributes to the users comfort while they are wearing the garment having the antenna.

The antenna may be removed from the garment prior to washing of the garment.

The antenna mounting may be removed from the garment prior to washing of the garment.

In accordance with a second aspect of the present invention there is provided an antenna suitable for use in a garment made in accordance with the first aspect of the present invention.

These and other aspects of the present invention appear in the appended claims which are incorporated herein by reference and to which the reader is now referred.

The present invention will now be described with reference to the Figures of the accompanying drawings in which:

Figure 1 is shows the principle functional components of a planar inverted F antenna;

Figure 2 is a perspective view of a patch antenna constructed to function as a planar inverted F antenna;

Figure 3a shows a front view of the patch antenna and part of an antenna mounting;

Figure 3b shows a rear view of the patch antenna and part of an antenna mounting;

Figure 4 shows an antenna mounting carrying the patch antenna;

Figure 5a shows the patch antenna and antenna mounting arranged on a wearer and viewed from a first perspective;

Figure 5b shows the patch antenna and antenna mounting arranged on a wearer and viewed from a second perspective; and

Figure 6 is a perspective view of a device for connecting an RF feed cable to a patch antenna.

It should be noted that the drawings are diagrammatic and not drawn to scale. Relative dimensions and proportions of parts of the Figures have been shown exaggerated or reduced in size for the sake of clarity and convenience in the drawings. The same reference signs are generally used to refer to corresponding or similar features in the different embodiments.

Referring to Figure 1, the principle components of a planar inverted F antenna (PIFA) comprise a first conducting ground plane 12, a second conducting plane 16 and a bridging portion 17 extending between the first plane 12 and second plane 16. The bridging portion 17 provides an electrical short between the first conducting ground plane 12 and second plane 16. As can be seen from Figure 1, the second conducting plane 16 and bridging portion 17 form an inverted 'L' section. A co-axial radio frequency (RF) feed cable 8 has inner conductor 8a connected to the second conducting plane 16 at location 18 and the co-axial cable 8 has outer conductor 18b connected to the first (ground) plane 12. The first and second plane 12, 16 are separated by a dielectric 14, which is shown here as an air gap. In essence the PIFA is a low profile resonant element which is about quarter of a wavelength long, in this case shown by dimension 'g'. When operating, currents oscillate in the inverted L section. The antennas impedance is determined by where the feed is connected in the 'g' direction along the 'L' section, and the impedance is lowered by connecting the feed nearer the short, that is nearer to the bridging portion 17.

Such an antenna may be built as a laminar construction 20 as shown in Figure 2. The antenna is provided with lower layer of conducting fabric 22 to

form the ground plane, on top of which is mounted one or more layer of insulating material 24 serving as the antenna dielectric, and positioned on the insulating material 24 is an upper layer 26 of conducting fabric which is approximately rectangular in shape and generally smaller in area than the lower layer 22. The upper and lower layers are connected by a neck portion 27 of conducting fabric. The upper layer 26 and neck portion 27 form the inverted 'L' section which faces the ground plane 22. Hence this construction forms a planar inverted F antenna, which is also known as a quarter wavelength patch antenna. The lower layer 22 and upper layer 26 are formed of a single piece of fabric which is folded back on itself at neck portion 27. It is not essential that the lower layer, upper layer and neck portion 22, 26, 27 are of the same piece of fabric and they may be formed of two or more pieces of fabric attached to one another. When separate pieces of fabric are indeed employed, the lower and upper layers, 22, 26, may be shaped separately and electrical connection established by sewing them together with electrically conductive thread, or by conductive gluing, or by sewing the conductive layers together using a seam which places them in pressurised contact.

An important requirement is that irrespective of how many portions of conductive fabric are used to make up the upper and lower layers, the ground plane (lower layer 22) should be of a larger area than the second plane (upper layer 26).

The components used in the antenna construction may be held together by thread, glue or other suitable methods.

A material suitable for providing the layers of conducting fabric is a woven nylon plated with a layer of copper or silver or nickel; the material known as "Shieldex" (Trade Mark) is suitable. The fabric is electrolessly plated. Electroless plating is a technique where the metal is deposited from solution directly onto the (chemically cleaned) material surface, which process gives a good mechanical bond in comparison with some other known electroplating techniques. As no resistive seed layers are involved during the deposition process, there is also improved radio frequency connectivity. Electrolessly plated rip-stop nylon was found to have excellent conductivity

and seems to be quite resistant to the onset of deterioration that may be caused by normal use and laundry wash cycles. For the insulating layers, materials typically used in the garment construction industry are suitable, such as acrylic, horse hair, cotton, polyester, wool and tailor's foam. Since the antenna can be of not insignificant area and will be mounted in a garment, it is advantageous that it is breathable and lightweight. Such requirements lead to one favoured insulating material being open cell foam.

The antenna 20 will normally be positioned in a garment such that the ground plane (lower layer 22) is adjacent the wearer in comparison with the upper layer 26. This is because the lower layer 22 is provided as the ground plane of the antenna 20, and the relative shapes of the layers are such that the ground plane extends substantially beyond the principle radiating edge 26a of the upper layer 26, so as to isolate the wearer from the strongest electromagnetic fields radiated from the antenna. In addition, the amount of signal absorbed by the wearer is reduced.

It will be understood that the antenna 20 can be flexed in use to conform to the shape of the garment it is accommodated within while the garment is being worn. The ability to flex seeks to minimise any awareness that the wearer may have of the presence of the antenna in the garment and therefore will not give rise to discomfort. The antenna will therefore be comfortable in use, whilst remaining fully operative even while being flexed.

The antenna 20 is supported by an antenna mounting 30. Part of the front side of the antenna mounting 30 is shown in Figure 3a while the corresponding rear side part of this mounting is shown in Figure 3b. As may be seen from those Figures, the mounting 30 comprises a body portion 31 which is generally symmetrical about a central vertical axis denoted A1 but tapered to be narrower towards a lower section 32 than an upper section 33. Such tapering contributes towards the body portion 31 of the antenna mounting 30 having a shape and size which is capable of being accommodated at least in part in the naturally occurring dip between a persons shoulder blades at the upper part of the back. A body portion 31 of suitable size and shape for incorporation into an adults jacket will have an

overall height (comprising upper section 33 and lower section 32) of around 20 centimetres. The overall thickness of the body portion 31 (incorporating the antenna) will be in the order of 1cm to 1.5cm.

The insulating material 24 forming the antenna dielectric is of open cell foam which contains a slit denoted in Figure 3a by broken line 25 and exaggerated in size for clarity. The upper and lower conductive layers 26, 22 respectively are of electrolessly plated rip-stop nylon with the neck portion 27 passing through slit 25. The open cell foam extends to perimeter portions 36 of the mounting 30 where it is attached by suitable means, such as by thread. As may be seen in Figure 3b, the lower layer 22 forming the ground plane also extends to the perimeter portions 36 of the mounting 30 where it is attached by any suitable means, such as by thread. In those cases where the chosen garment construction method dictates that the lower layer 22 is too small to form a ground plane of sufficient area, an extra conductive layer may be provided adjacent to and in electrical contact with the lower layer 22 which extends to the perimeter portions 36 of the mounting 30.

Extending from upper adjacent corners 37a, 37b of the body portion 31 are support straps 38a, 38b. The body portion 31 and support straps 38a, 38b together form an antenna mounting resembling a 'yoke' arrangement 40 which may be attached to a garment to provide a means for mounting the antenna in a garment. While a garment including the yoke-type antenna mounting is being worn, the arrangement of the yoke-type antenna mounting is illustrated in Figures 5a and 5b (the garment itself is not shown for the sake of clarity). Figure 5a shows a person from behind and the antenna 20 and body portion 31 are located in the vicinity of the wearers back between the shoulder blades. Figure 5b shows a person from the front and the support straps 38a, 38b are shown to extend from the body portion 31, over the shoulders of the wearer and down the front of the wearers torso. By extending the support straps in this way, their weight serves to counter balance the weight of the antenna 20 and body portion 31 to provide more even weight distribution of the antenna 20 and antenna mounting combined between the front and back of the wearer and centred on the wearers shoulders. Such weight distribution seeks to

improve the comfort of a garment provided with an antenna and the antenna supporting mounting and will generally contribute to the correct 'hang' of the garment itself. Straps 38a, 38b will be typically 80cm long for a yoke-type antenna mounting intended for fitting to an adult sized jacket although the length may be altered accordingly to obtain the correct weight distribution and to be suitable for incorporation in the garment. The yoke-type antenna mounting may be of any suitable flexible material, in particular a fabric, for example nylon. In the configuration shown, the antenna mounting has straps 38 and perimeter portions 36 of the body portion 31 are made from Cordura, with the perimeter portions containing polyester filling or polyurethane foam. Figure 4 shows the co-axial feed cable 8 attached to one of the support straps 38a or 38b by loops of thread. The feed cable 8 terminates with connector 8c for connecting the antenna to telecommunications equipment. If desired, the antenna mounting may carry electronics as well as the antenna.

The antenna mounting and antenna may be included in a garment permanently by building it into the lining. Alternatively the antenna mounting and antenna may be removably fastened to the garment allowing it to be removed therefrom prior to washing the garment or for use in another garment. The antenna mounting may be included in garments that may be worn about the upper part of the body, such garments including jackets or coats. The fact that the yoke type antenna mounting has straps extending from the rear and along the front of a garment while it is being worn means that the antenna mounting can be used to carry wiring and connectors for connecting together various pieces of electronic equipment that are being carried by a user, such equipment including audio reproduction devices, telecommunications equipment, microphones, earphones and user input devices and wearable computing apparatus. The materials of the antenna and antenna mounting holder are preferably chosen to be permeable to air in order to allow the parts of the users body that they cover during use to be able to 'breathe'.

The conductors of the feed cable 8 may be attached to the conductive layers of the fabric antenna by known methods such as soldering (although such a technique is not ideal) or possibly using a clamping arrangement. One

preferred connection technique is to use connection device 60 illustrated in Figure 6 which is inserted between the lower conductive layer 22 and upper conductive layer 26 of the antenna 20, with device conductive microstrip 66 in contact with antenna upper layer 26 and device lower conductive surface 63 (not shown) in contact with lower antenna conductive layer 22. This device and connection technique is the subject of co-pending British patent application number GB0100774.9 (applicants reference PHGB 010004) filed on 11th January 2001 in the name of Koninklijke Philips Electronics N.V. entitled 'Connector Device', the teaching of which is incorporated herein by reference.

In general, location of an antenna around the upper regions of a wearers body is preferred because there is less chance of the antenna being obscured during use.

One example patch antenna suitable for use with GSM 900MHz applications is a quarter wavelength PIFA which has an upper conductive layer 26 which has been made especially wide to reduce conductor losses. The patch is approximately 70mm square. The separation of the upper and lower antenna conductive layers is around 12.5mm. The large width and height of the antenna upper conductive layer results in the antenna being unusually inductive. This can be compensated for by a method that is described in more detail in the above mentioned co-pending British patent application number GB0100774.9 (applicants reference PHGB 010004) filed on 11th January 2001 entitled 'Connector device', the teaching of which is incorporated herein by reference. It has been found that positioning the RF feed to the side of the antenna at around 20mm from the short 27 (see Figure 2) provides a good electrical match. The measured antenna performance showed a match across the extended GSM band of 880 to 960MHz having better than 6dB return loss. While the antenna is not being worn, efficiency is around 70% to 80%. This drops to around 50% when the antenna is being worn, and seems to be reasonably independent of who the user is, which is in contrast to the case where the antenna is included in a mobile telephone. However, the relatively large ground plane formed by a lower layer 22, which is ideally 10cm or more

across, contributes towards isolation of the antenna fields from the users body to reduce the energy absorbed by the user. Such a ground plane cannot normally be accommodated in a mobile telephone so in-built phone antennas will generally have lower efficiencies (due to user absorption) of only 30% to 50% at best, dropping to only 3% to 5% at worst.

While a 900MHz antenna construction has been described in some detail it will be appreciated by the person skilled in the art that antennas may be constructed to be used at other frequencies, for example around 1800MHz.

While the present invention has been described in the context of a patch antenna in the form of a planar inverted F antenna, it is possible to use other types of antenna such as a half wave patch antenna. Such an antenna is similar in mechanical construction to the quarter wave planar inverted F antenna but does not have the short (bridging portion 17 of Figure 1 / neck portion 27 of Figure 2) between the first and second conductive layers of the patch antenna. Indeed it is possible that the antenna may be of an alternative type having laminar construction or even an antenna of an entirely different type, for example an induction coil, whilst still remaining within the scope of the present invention.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design, manufacture and use of garments, antennas (including antennas of laminar construction (fabric or otherwise)) and applications thereof and which may be used instead of or in addition to features already described herein.

CLAIMS

1. A garment comprising an antenna and means for connection of the same to a portable electronic device to permit wireless communications of said device via said antenna;

characterised in that the garment is shaped to be worn about the upper body of the user and the antenna is supported by an antenna mounting of the garment so that when the garment is being worn the antenna is held in the vicinity of the back between the shoulder blades and the antenna mounting is configured with a shape and size to accommodate the antenna in the vicinity of the back between the shoulder blades.

2. A garment in accordance with claim 1 wherein the antenna mounting includes a body portion configured with a shape and size such that it is capable of being at least partially accommodated in the vicinity of a wearers back between their shoulder blades.

3. A garment in accordance with claim 1 or 2 wherein the antenna mounting includes straps which extend during use over the shoulders of a wearer towards the front of the wearers torso.

4. A garment in accordance with claim 3 wherein the straps are configured to extend during use at the front of the wearers torso to at least partially counterbalance the weight of the antenna.

5. A garment in accordance with claim 1, 2, 3 or 4 wherein the antenna is a patch antenna device.

6. A garment in accordance with claim 5 wherein the antenna includes first and second spaced layers of electrically conducting material; a layer of electrically insulating material between the first and second layers; and

connection means by which the first and second layers are connectable to telecommunications equipment.

7. A garment in accordance with claim 6 wherein the antenna includes further connection means by which electrical contact is made between the first and second layers.

8. An garment in accordance with claim 6 or 7 in which the layer of electrically conducting material adjacent a wearer of the garment is of substantially greater area than the area of the other layer of electrically conducting material and is connected as the antenna ground plane.

9. A garment in accordance with claim 6, 7 or 8 wherein the first or second layer or both of the first and second layer of conducting material is a fabric.

10. A garment in accordance with claim 9 wherein the fabric is electrolessly plated rip stop nylon.

11. A garment in accordance with any one or more of claims 6 to 10 wherein the layer of insulating material is open cell foam.

12. A garment in accordance with any one or more of claims 1 to 11 wherein the antenna is removable from the garment prior to washing of the garment.

13. A garment in accordance with any one or more of claims 1 to 12 wherein the antenna mounting is removable from the garment prior to washing of the garment.

14. An antenna suitable for use in the garment of any one or more of claims 1 to 13.

15. A wearable back mounted patch antenna shaped and sized to fit in the vicinity of the back between the shoulder blades while being worn by a user.

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16. An antenna mounting having the technical features of the garment antenna mounting of any one or more of claims 1 to 13.

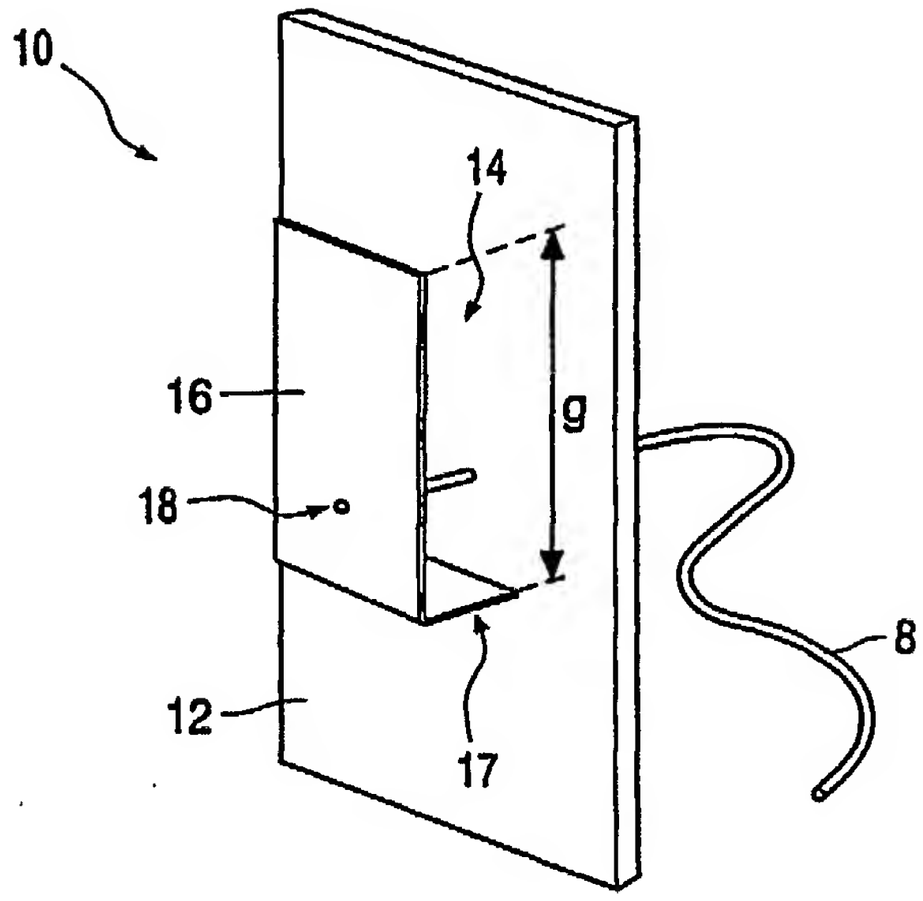

FIG. 1

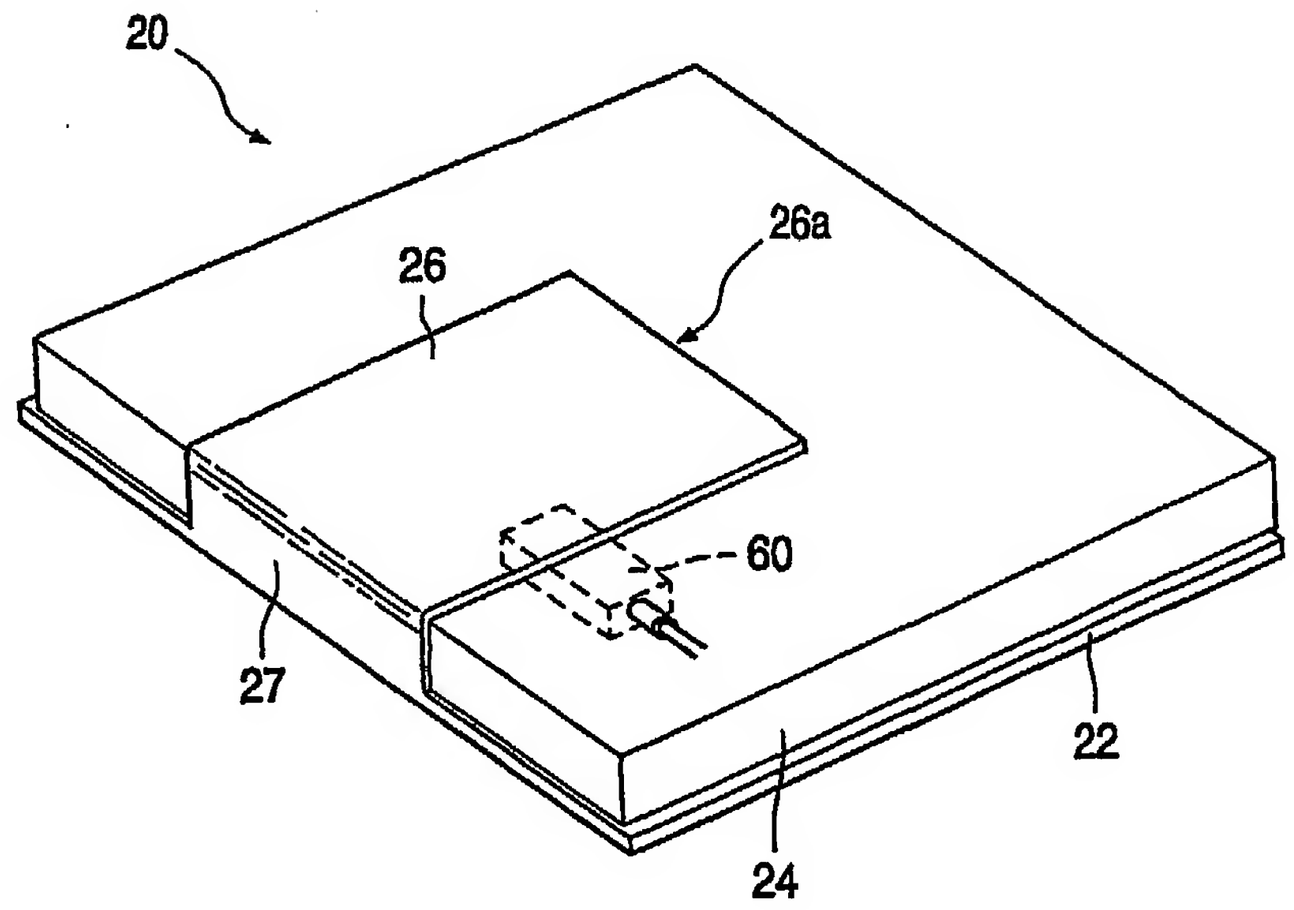

FIG. 2

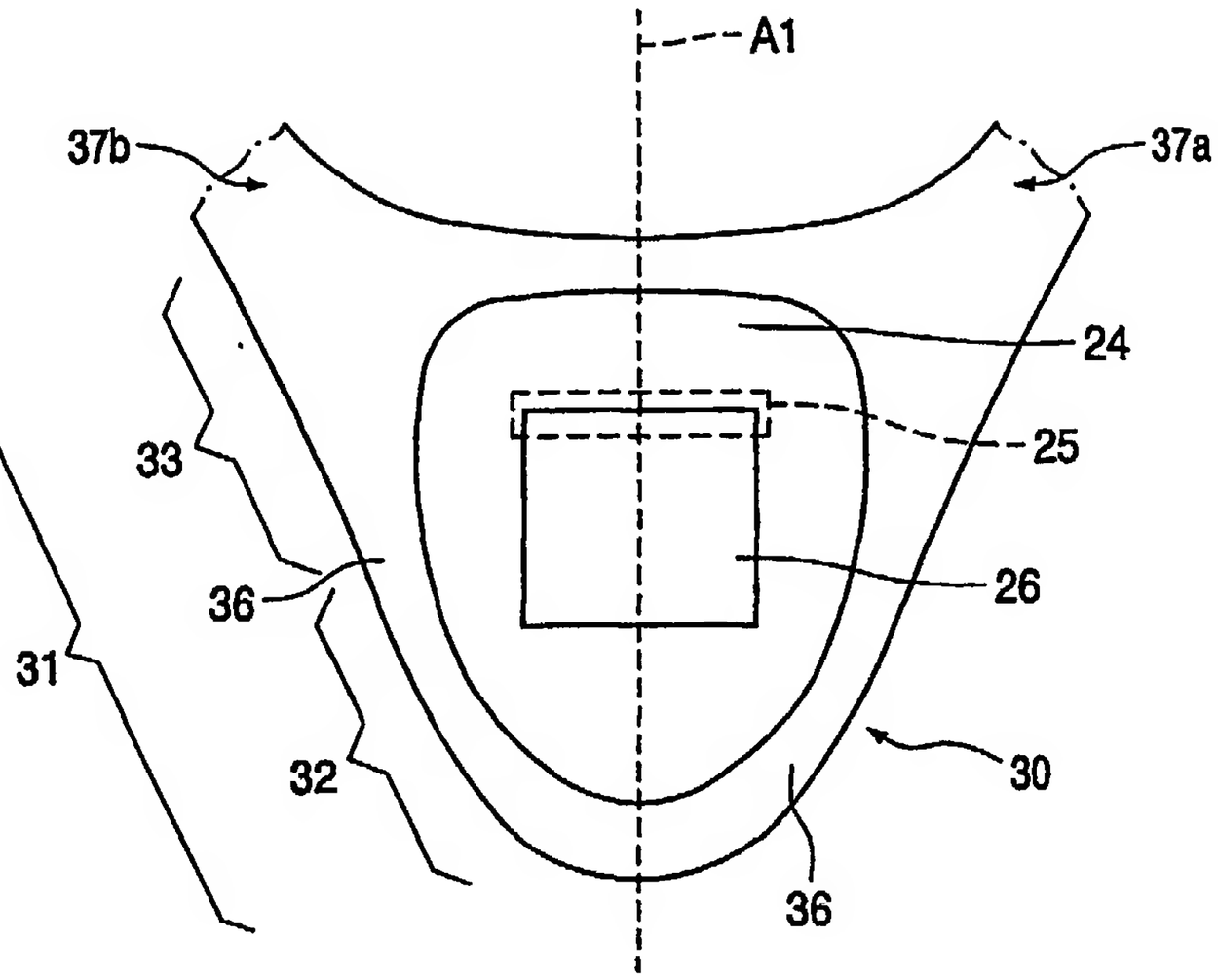

FIG. 3a

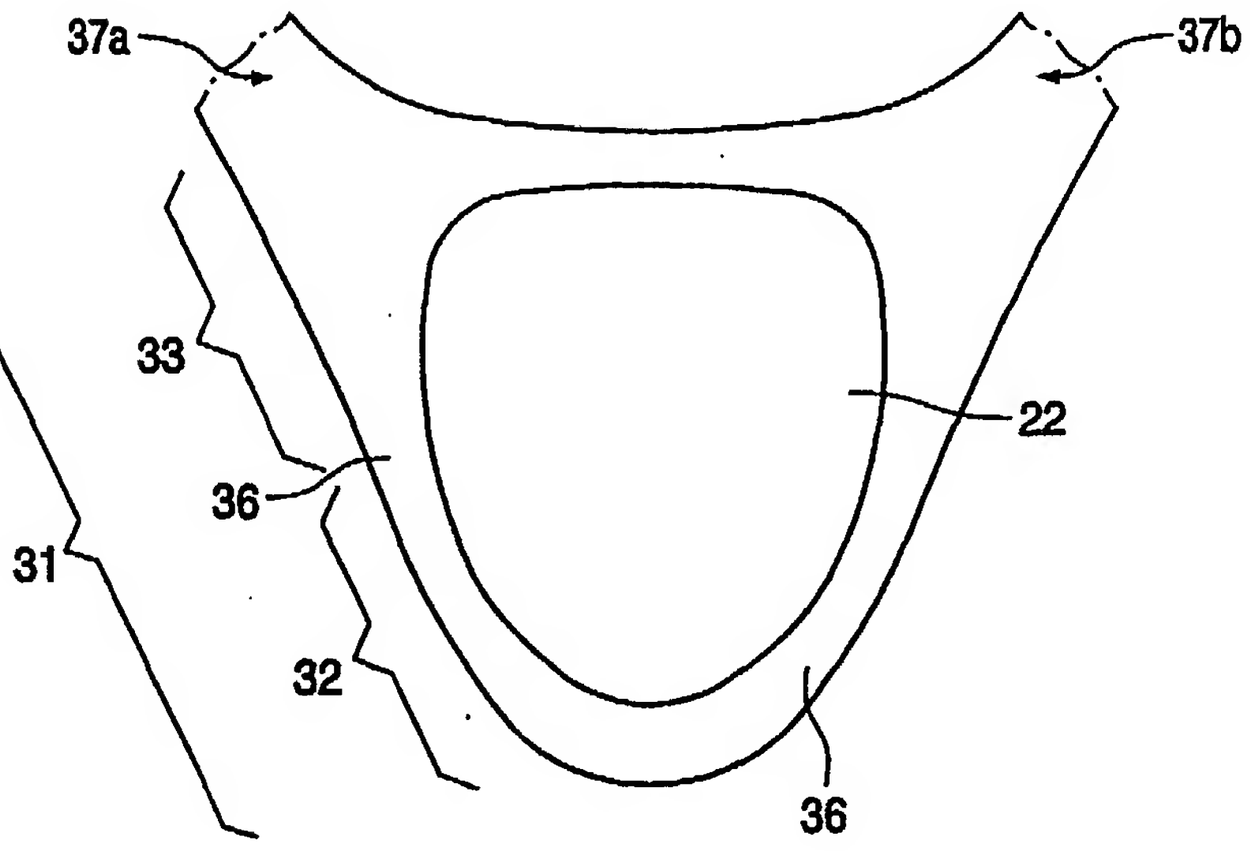

FIG. 3b

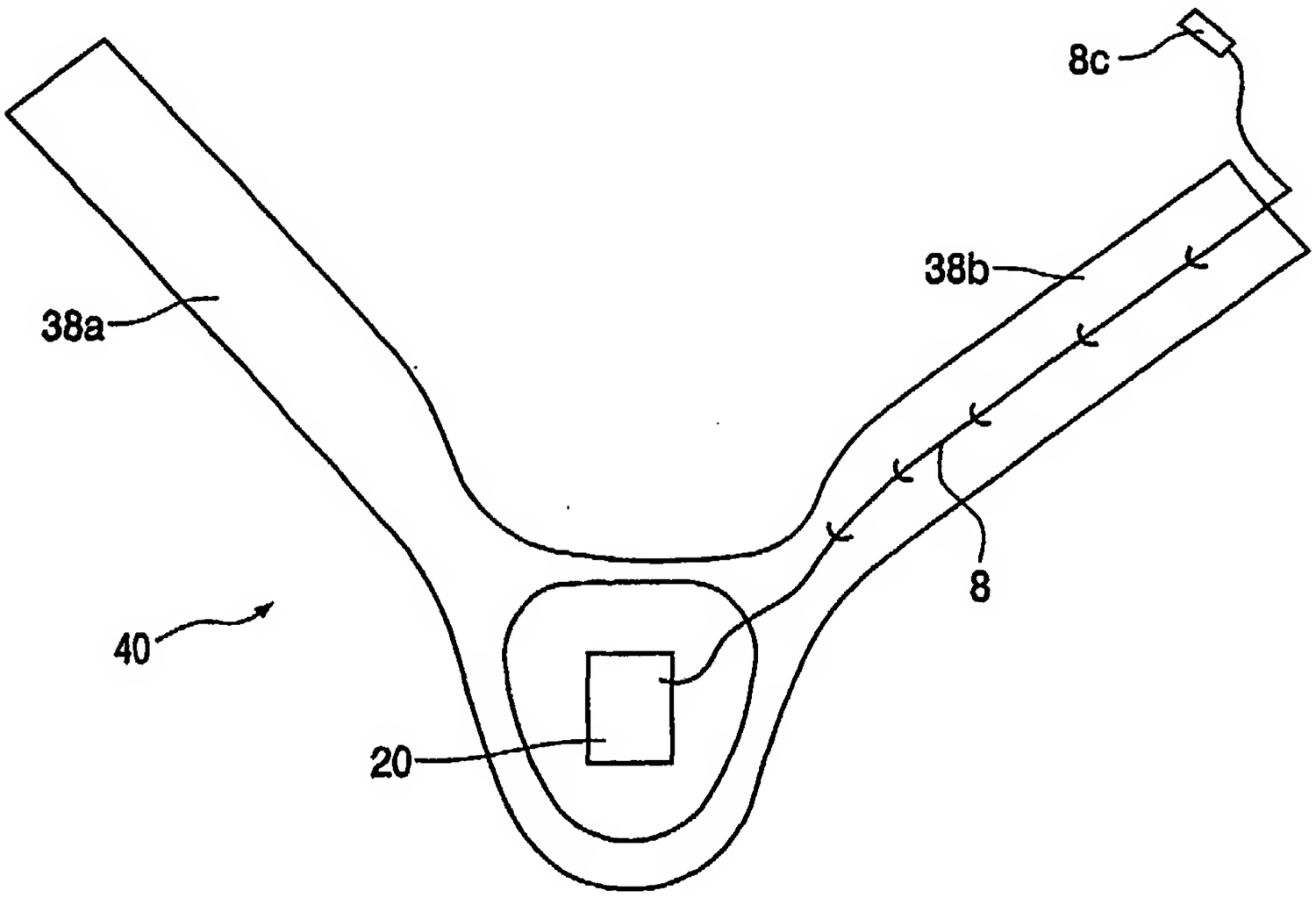

FIG. 4

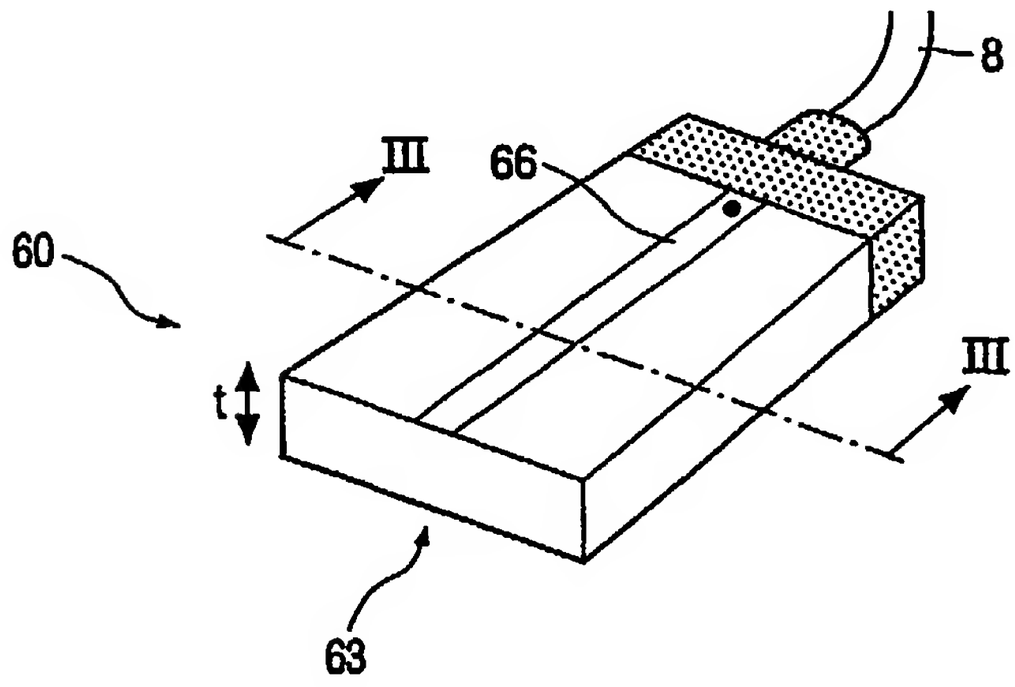

FIG. 6

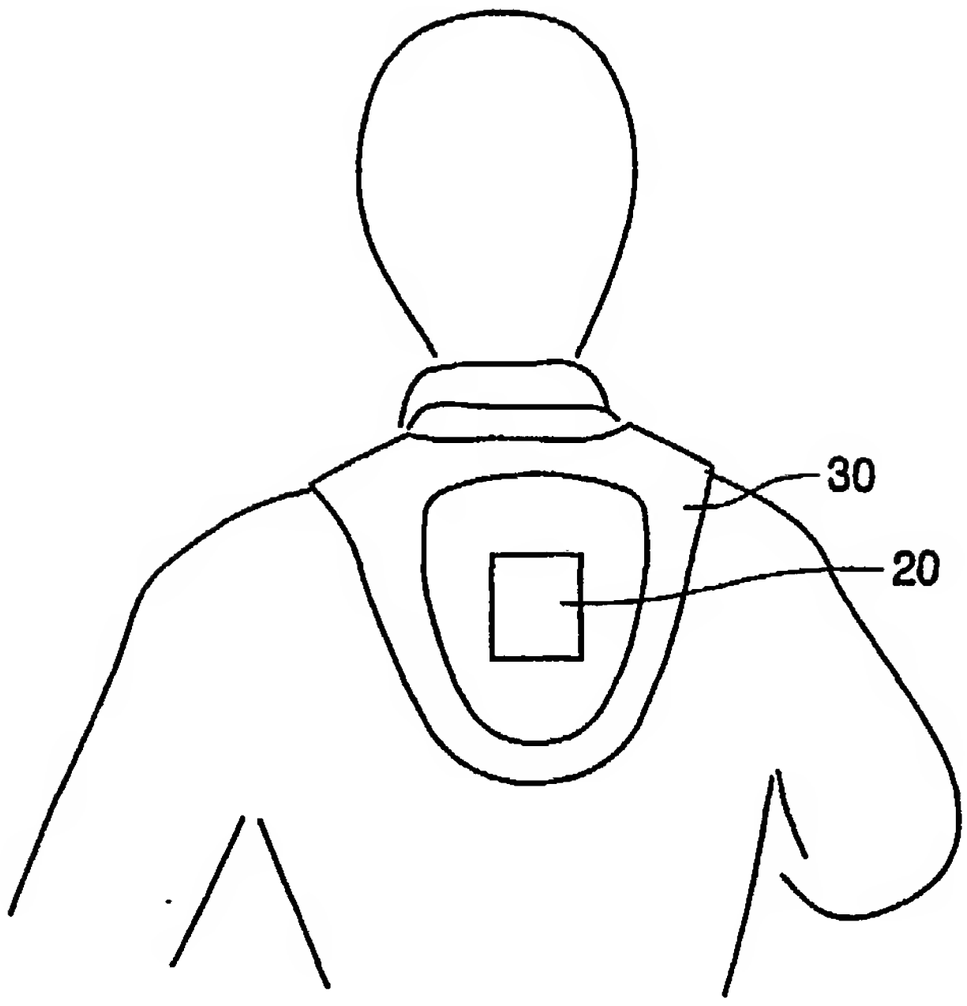

FIG. 5a

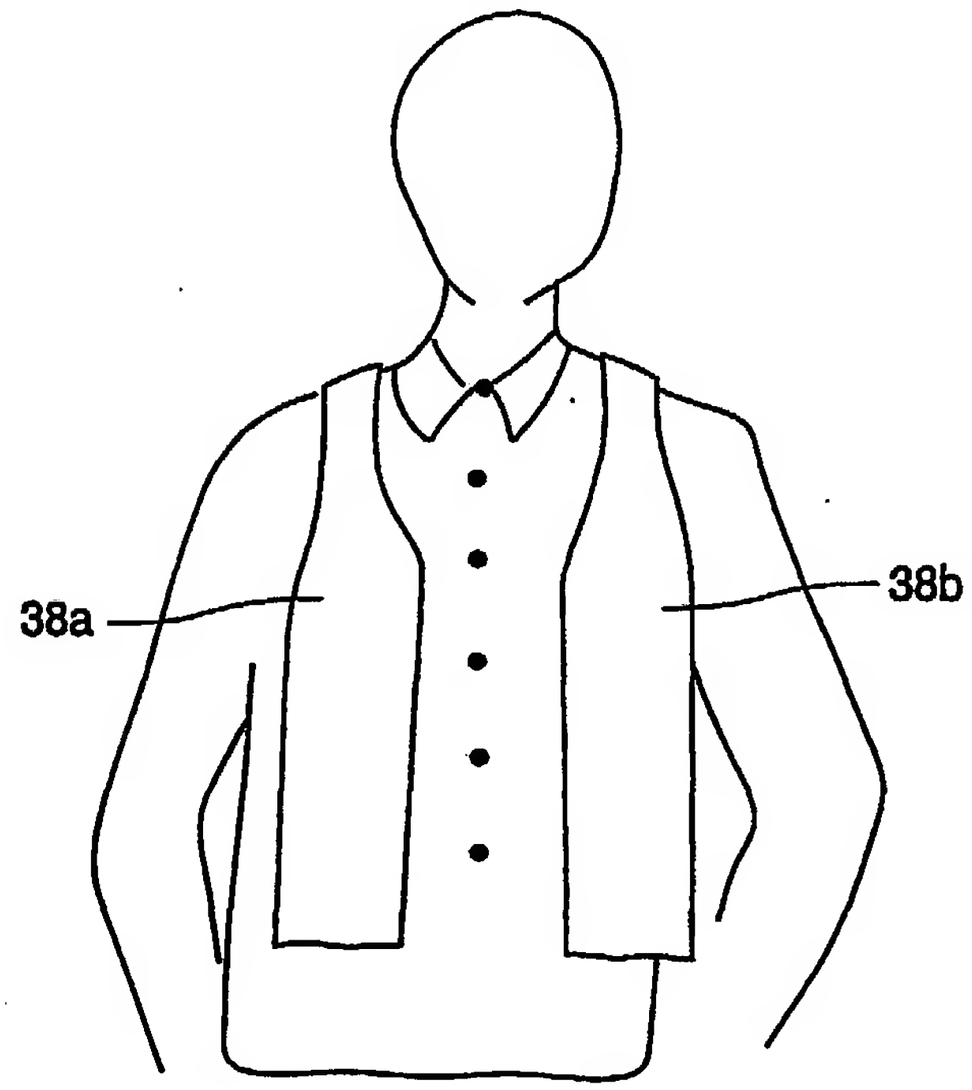

FIG. 5b

INTERNATIONAL SEARCH REPORT

Inter[illegible]l Application No
PCT/IB 02/00017

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01Q1/27 A41D1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01Q A41D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 198 43 237 C (KLAUS STEILMANN INST FUER INNO) 18 May 2000 (2000-05-18) column 3, line 42-60; figure 2 ---	1,2, 14-16
A	DE 198 13 704 A (ROHDE & SCHWARZ) 30 September 1999 (1999-09-30) claims 1,2,4 ---	1,14-16
A	GB 2 036 447 A (PYE LTD) 25 June 1980 (1980-06-25) page 1, line 115 -page 2, column 14; figure 1 -----	1,14-16

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 March 2002	28. 06. 2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Van Dooren, G

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 02/00017

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-4, 14-16

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/IB 02/00017

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-4,14-16

   weight of garment, antenna and antenna mount

2. Claims: 5-11

   size of antenna

3. Claims: 12,13

   cleaning of garment

INTERNATIONAL SEARCH REPORT

formation on patent family members

Int al Application No
PCT/IB 02/00017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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